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National Institute of Standards and Technology
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The Building and Fire Research Laboratory web site is http://www.bfrl.nist.gov

Technical Publications

Building and Fire Research Laboratory's 1996 publication abstracts are found in *Publications 1996*, NIST SP838-12. Full text, tables and figures are available on 2 CD-ROM's, NIST SP 914. Also, summaries of BFRL's research are available as *1997 Project Summaries*, NIST SP 838-13. This material is available from BFRL's Office of Cooperative Research Programs, National Institute of Standards and Technology, Gaithersburg, MD 20899, Facsimile (301) 975-4737.

Left: The launch of STS-94 on 1 July 1997

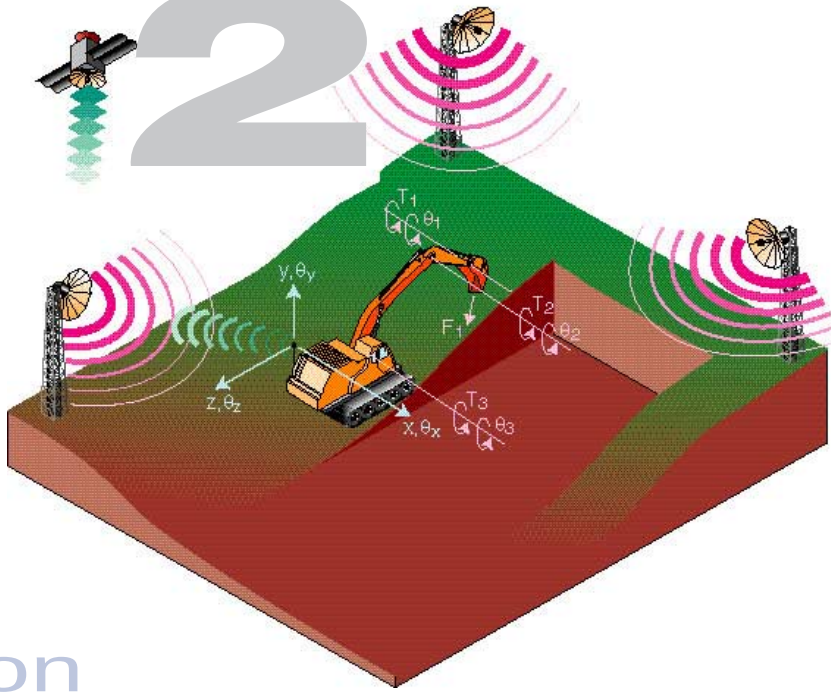
Director's Foreword

Staff of the Building and Fire Research Laboratory

1 Performance

Advanced photodegredation device capable of exposing polymeric materials to a highly, spatially uniform ultraviolet radiant flux.

2 Automation



Simulation of computer automation at the construction site

3 Loss Reduction

Fire Test of interaction of sprinklers, draft curtains and heat and smoke vents

1 High Performance Materials and Systems for Constructed Facilities

It is estimated that increased energy usage due to moisture is approximately $150 million dollars per year.

Mold and mildew as a result of poor moisture control

1.1 MOIST 3.0

Douglas Burch of the Building Environment Division has completed and released an enhanced version of MOIST, a personal computer program that predicts the transfer of heat and moisture in walls, flat roofs and cathedral ceilings. MOIST 3.0 represents a significant advancement over the previous DOS based version. MOIST 3.0 utilizes an easy to use graphical user interface that allows the user to construct virtual building assemblies and quickly assess the resulting thermal and moisture performance.

The program contains an extensive heat and moisture property database for building materials and hourly weather data for 51 cities within the United States and Canada. Unlike the previous version of MOIST, MOIST 3.0 incorporates algorithms that predict the indoor relative humidity of the building being analyzed rather than assuming a fixed relative humidity. This capability is useful in determining if ventilation strategies provide a means of achieving acceptable moisture performance.

The program is used by building practitioners to: 1) determine if vapor retarders are needed in cold climates and if so where they should be placed; 2) predicting surface relative humidity at the construction layers in hot and humid climates, thereby determining the potential for mold and mildew growth; 3) determine the drying rates for materials containing original construction moisture; and 4) to investigate the moisture performance of cold refrigeration storage rooms. Moisture analysis makes it possible to design building constructions that perform with considerably less moisture-induced material degradation.

It is estimated that increased energy usage due to moisture is approximately $150 million dollars per year. If through the use of MOIST, moisture accumulation in 20 percent of the affected roofs and walls was eliminated, an annual savings of $30 million per year would result. Proper moisture analysis and construction would also decrease the enormous expenditure of funds required to replace moisture damaged building materials and coatings as well as reduce the litigation associated with moisture-related damage.

The previous DOS-based MOIST is being used by over 1,200 building practitioners. It is anticipated that the new release will be in greater demand due to its ease of use and enhanced analysis capabilities.

Contact: Dr. A. Hunter Fanney, (301) 975-5864, MOIST@nist.gov

Placing tape-bonded seam specimens in the chamber prior to conducting a creep-rupture test

1.4 Predicting Service Life of Chloride-Exposed Steel-Reinforced Concrete

Dale Bentz, James Clifton and Kenneth Snyder have developed a prototype computer-integrated knowledge system (CIKS) for predicting the service life of steel-reinforced concrete exposed to chloride ions, as in a concrete bridge deck treated with de-icing salt. Starting from the mixture proportioning process, the system proceeds to predict chloride diffusivity coefficients and, finally, to predict the ingress profiles and time to corrosion initiation for a reinforced concrete exposed in a specific environment. Apart from its intrinsic value as a tool for designers, the system demonstrates the potential for disseminating knowledge on specific topics in concrete technology to the construction industry through the World Wide Web.

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1.5 Evaluation of New Technology for Seams in Elastomeric Roofing

Elastomeric roofing membranes based on EPDM rubber have excellent weather-resistance and are one of the main types of membrane used on low-slope roofs. A critical element of elastomeric roofing membranes is the seams which are generally formed in the field. The liquid-applied butyl adhesives which have been extensively used in forming EPDM roofing seams since the mid-1980s have been successful. However, these adhesives contain a large fraction of volatile organic solvents, which could be a problem for the roofing industry if environmental regulations become more restrictive. An alternative that has been proposed is butyl tape systems which contain lesser amounts of solvent. To evaluate the reliability of adhesive joints made with tape systems, a NIST-led consortium of individual companies and two trade associations has been studying the tape adhesives for two years. The statistically-designed experiments have investigated the times-to-failure of seams under various loads and under various environmental conditions. The results to date suggest that seams made with tape adhesives perform at least as well as those made with liquid-applied butyl adhesives and that they may be considered a viable alternative.

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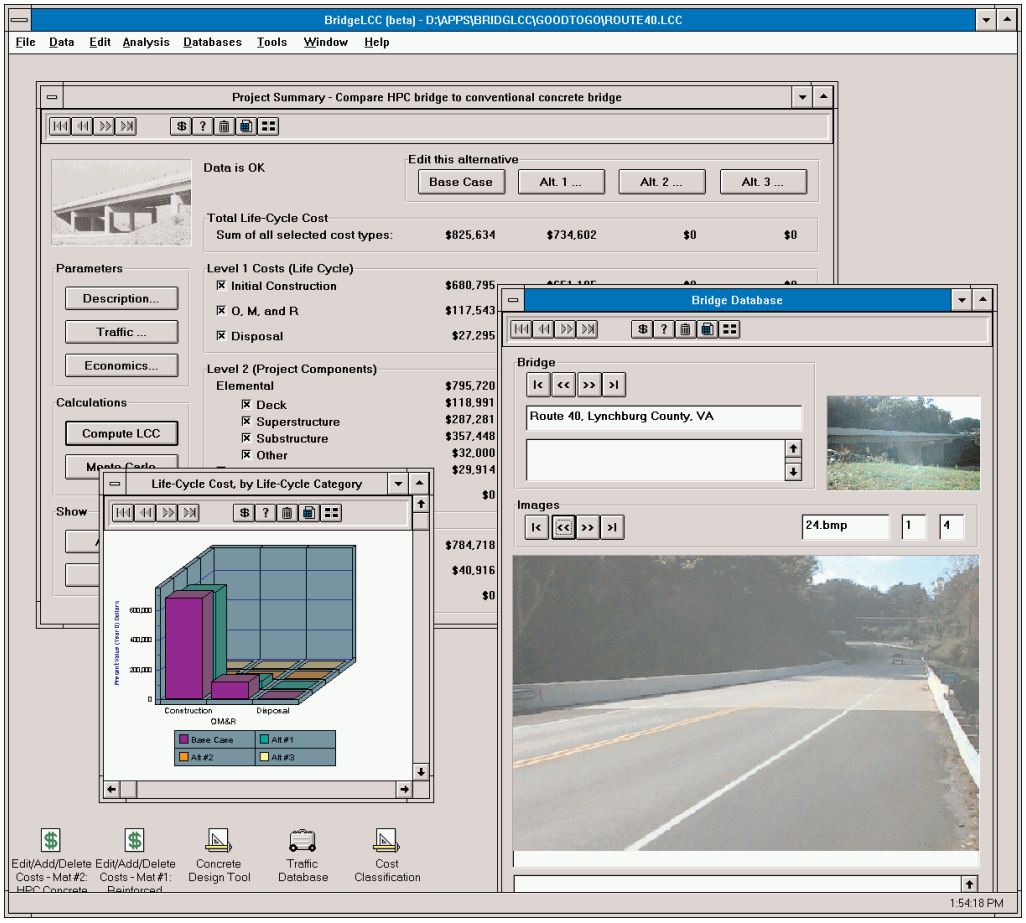
1.6 Knowledge System for Protective Coatings for Steel

Organic coatings provide a versatile, cost-effective means for protecting steel structures against adverse environmental conditions, but decisions about coating system selection are often difficult to make. Currently, users of coating systems must rely on information presented in many different forms. These include manuals, guides, photographs and drawings, videos, databases and other sources. In addition, a human expert's advice may be needed to reach a decision, or the needed knowledge may not be accessible. To provide a comprehensive, easily-accessible source of reliable information, BFRL has worked with the SSPC (formerly the Steel Structures Painting Council and now renamed the Society for Protective Coatings) to develop the Coatings Expert



BridgeLCC calculates the life-cycle costs of bridges built from competing alternative materials

1.8 Economic software for Assessing the Life-Cycle Costs of High-Performance Bridge Materials

Mark Ehlen, an engineer in BFRL's Office of Applied Economics, has completed the alpha version of BridgeLCC, user-friendly Windows-based software for evaluating the life-cycle costs of highway bridges. Based on an economic model developed by Ehlen and Harold Marshall, BridgeLCC is specifically designed to analyze the life-cycle costs of new construction materials such as high-performance concrete, high-performance steel and fiber-reinforced-polymer composites. The software includes a BFRL-developed concrete service life tool, a Monte Carlo module for analyzing uncertain costs and a standard bridge elemental classification under joint development by BFRL and industry. Ehlen is working with the Federal Highway Administration to implement the beta version at state departments of transportation, giving them an evaluation tool to help them reduce the life-cycle costs of building and repairing bridges by using new, higher-performance materials.

Contact: Dr. Mark A. Ehlen, (301) 975-4522, mark.ehlen@nist.gov

1.10 ASTM ISR Reference Soils Project

BFRL's AASHTO Materials Reference Laboratory (AMRL) sponsored by the American Association of State Highway and Transportation Officials (AASHTO) is supporting the ASTM Institute of Standards Research Reference (ISR) Soils and Testing Program. The purpose of this program is to prepare precision statements for 13 ASTM test methods and have a stockpile of four soil types to benefit the engineering community. The soil samples can be used by laboratory accreditation systems, quality control and quality assurance activities and standards development. AMRL has processed more than 41,000 kg of the four soil types into samples ready for shipment to laboratories, provided statistical support in conjunction with the NIST Information Technology Laboratory and participated on the project management team.

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1.11 Implementation of Strategic Highway Research Program Technology

AMRL is continuing to support implementation of results from the Strategic Highway Research Program (SHRP). AMRL has assisted the AASHTO Subcommittee on Materials in drafting and processing more than 60 provisional standards based on SHRP technology. AMRL has added SHRP performance graded binder and hot-mixed asphalt samples to its Proficiency Sample Program and inspects laboratories who perform related test methods as part of its Laboratory Inspection Program. AMRL is also supporting SHRP implementation through its technical support of the AASHTO Accreditation Program. Private industry laboratories testing asphalt binders are required to be accredited by the year 2000. Haleem Tahir is serving on five National Cooperative Highway Research Program panels that guide the follow-on research on SHRP technology dealing with aggregates and asphalt mix design. He also helped develop the concept of the AASHTO Lead States Program, which was developed to ensure that practical, real world experience is gained in the early application of SHRP technology. This program has been instituted and is considered to be a most successful program in technology transfer.

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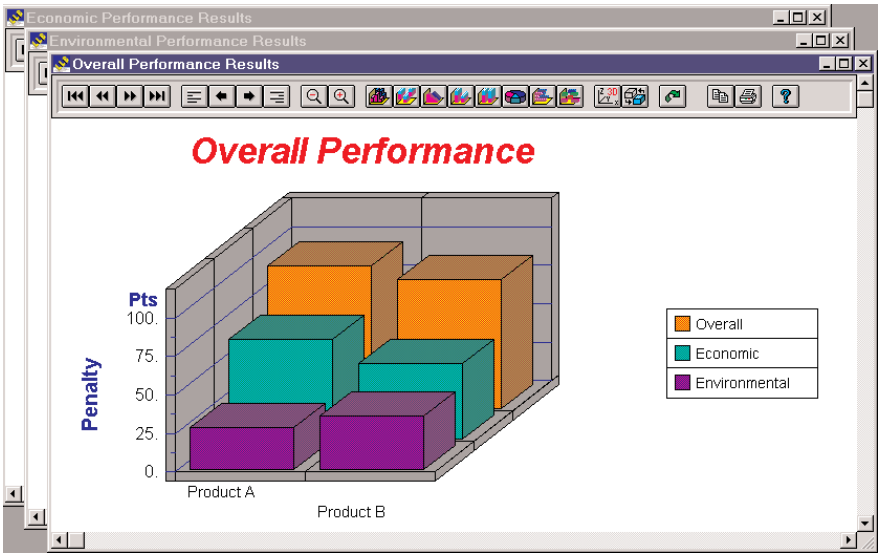
2 Automation in Construction and Constructed Facilities

2.1 BEES

Under Barbara Lippiatt, of the BFRL Office of Applied Economics, the BEES (**B**uilding for **E**nvironmental and **E**conomic **S**ustainability) project has developed a powerful technique for balancing the environmental and economic performance of building products. Implemented in Windows-based decision support software aimed at designers, builders and product manufacturers, the tool includes actual environmental and economic performance data for a number of building products. After incorporating comments received during a 1997 beta test by over 125 reviewers worldwide, the first version of the tool, BEES 1.0, will be published in January 1998. The intended impact is lowered building-related contributions to environmental problems at minimum cost.

The intended impact is lowered building-related contributions to environmental problems at minimum cost

BEES measures the environmental performance of building products using the environmental life-cycle assessment approach specified in the latest versions of ISO 14000 draft standards. The approach analyzes all stages in the life of a product, including raw material acquisition, manufacture, transportation, installation, use and recycling and waste management. Economic performance is measured using the ASTM standard life-cycle cost method. The technique includes the costs over a given study period of initial investment, replacement, operation, maintenance and repair and disposal. Environmental and economic performance are combined into an overall performance measure using the ASTM standard for Multi-Attribute Decision Analysis.



Preliminary demonstrations have been made to industry participants showing the ability to track a full-scale 30-ton bridge crane (one component of NCAT) and the components it is maneuvering in 3D in real-time and to display the status of the job site to a remote management center

2.3 Visual Test Shell for BACnetP

Visual Test Shell (VTS), a software tool developed by NIST for testing building control products for conformance to ASHRAE Standard 135-1995, BACnet, was released in 1996. BACnet is a communication protocol standard that enables the interconnection of building control products made by different manufacturers. This standard creates the opportunity for building owners to bid control system projects competitively and to integrate traditionally stand-alone building services such as energy management, fire detection, security and building transportation. It will also play an important role in interactions between building control systems and a deregulated utility industry. VTS is now being used by manufacturers who are developing BACnet products. The testing procedures implemented in VTS have become the basis for a draft addendum to the BACnet standard that defines a conformance test suite. VTS will continue to develop as the standardization process proceeds. The goal is for VTS to become the tool used to implement an industry-run certification program for BACnet products.

The emergence of building control products that utilize the BACnet protocol has significantly increased the interest in BACnet outside of the United States. BACnet has been adopted as a pre-standard in the European Community (ENV 1805-1) and has been adopted as the working draft for an ISO standard by ISO/TC 205/WG 3 Building Control System Design. BACnet has been included in the specifications for the new German Parliament complex at the Reichstag in Berlin. The Reichstag project is one of the most high profile construction projects in Europe today. There are now at least 2,500 BACnet systems installed worldwide and they can be found in at least 14 countries.

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2.4 NIST National Construction Automation Testbed: Developing Interface Data Standards for Real-Time Construction Site Metrology

An exciting collaborative effort is under way between the Building and Fire Research Laboratory (BFRL), the Manufacturing Engineering Laboratory (MEL) and the U.S. construction industry to develop the information infrastructure that will lead, ultimately, to the general use of automated metrology systems and semi-automated machinery on the average construction job site.

A multi-disciplinary team has been formed within NIST, drawing expertise in the fields of CAD/CAE information systems and data exchange standards, real-time construction site metrology; wireless data telemetry; VR world modeling; and intelligent systems design. The first product of this collaboration, the National Construction Automation Testbed (NCAT) is "under construction" at NIST for test and validation of proposed open architecture data exchange and protocol standards; real-time construction site metrology techniques, including seamless hand-off between metrology systems; and the development of standard component identification protocols for barcode, smart chip and RFID tags. Preliminary demonstrations have been made to industry participants showing the ability to track a full-scale 30-ton bridge crane (one component of NCAT) and the components it is maneuvering in 3D in real-time and to display the status of the job site to a remote management center (the National Advanced Manufacturing Testbed laboratory,

3 Loss Reduction

3.1 New Class of Fire Retardants

As materials evolve to a higher degree of functionality and safety, new types of formulations are needed to meet fire safety standards. BFRL scientists Jeffrey W. Gilman and Takashi Kashiwagi, working with Emmanual Giannelis of Cornell University, have been examining novel materials formed by reacting a host organic resin with special fine clay particles. At low clay additions (under 10% by mass) a polymer layered silicate nanocomposite is formed. The team has shown that these materials also offer a new means for achieving a high degree of fire retardancy. Prior NIST research has shown that the rate of heat release during a fire is the principal property controlling fire growth and thus fire loss. Reacting nylon-6 with only 5% of this clay results in a product whose peak rate of heat release is reduced by a factor of 3. The mechanism that results in this significant improvement in fire safety is different from that in simple mixtures and is leading to approaches for other resins. The results have attracted international attention and a consortium of U.S. polymer and polymer product manufacturers is being formed to accelerate this technology.

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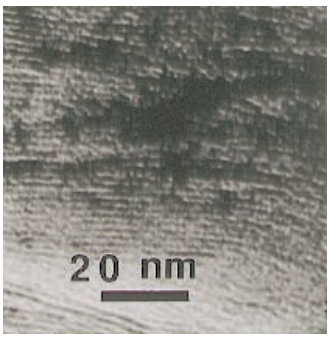

Transmission electron micrograph of char from combustion of nylon-6 silicate nanocomposite

3.2 Suppression of Electrical Fires

A fire in a telecommunications facility can have such a severe impact on service that it is important to effect fire suppression while keeping the equipment functioning. For years, halon 1301 (CF_3Br) has been the chemical agent used to accomplish this. However, this chemical is a significant depleter of stratospheric ozone, with international restrictions on its production and use. Working with the 3M Company, William Grosshandler and Emil Braun are determining the fire suppressant criteria for controlling fires in energized electrical equipment. Current standards presume that the needed concentration of fire suppressant will be the same as for non-electrical fires. Tests by 3M had shown that as much as twice the agent may be needed. BFRL staff have now conducted a series of tests to measure analogous ratios for suppressing and preventing re-ignition of the radiation-enhanced burning of a rod of solid fuel. The required concentrations of two inert gases and four halocarbon agents were

Dr. William Grosshandler, Leader, Fire Sensing and Extinguishment Group, is developing a new test method in cooperation with 3M to quantify the impact of the radiant flux from an electrical heater (seen as the truncated cone) on the minimum concentration of a gaseous agent necessary to extinguish a burning plastic specimen.

3.5 Fire in Space

Gregory Linteris, NIST's first astronaut, has completed two flights as a payload specialist on the Space Shuttle Columbia. STS-83 was the first Microgravity Science Laboratory mission. Launched in April 1997, its goal was to focus on materials and combustion research in microgravity. The mission was curtailed after only a few days due to mechanical problems with the spacecraft. However, on July 1, 1997, Dr. Linteris and the rest of the STS-83 crew were launched into space as part of mission STS-94 to complete the experimentation considered vital by NASA management.

The results exceeded everyone's expectations, providing fundamental new knowledge in the scientific fields of combustion, biotechnology and materials processing. More than 200 fires, or combustion experiment runs were conducted on MSL-1. A study of the phenomena of soot resulted in discovery of a new mechanism of flame extinction caused by radiation of soot. Scientists found that the flames emit soot sooner than expected. These findings have direct impact on the theories predicting the formation of soot, a major factor as a pollutant and in the spread of unwanted fires.

A second combustion study on spherical flame structures or flameballs, resulted in the weakest flames ever burned either in space or on Earth and the longest ever ignited in space. This provides new information for models of weak combustion processes needed to develop cleaner, more fuel-efficient internal combustion engines. In a third combustion study, individual and paired droplets of fuel were ignited and information collected on the burn rates, flame shape and radiation emitted. The resulting information will improve theoretical models of combustion of atomized fuels, such as experienced in engines and spray fires.

Contact: Dr: Gregory Linteris, (301) 975-2283, linteris@cfr16.cfr.nist.gov

Dr. Gregory Linteris, mechanical engineer and NASA payload specialist is performing materials and combustion science research in the orbiting STS-94 Microgravity Space Science Laboratory

Damaged Interior of the Albertsons store in Williamson County, Central Texas after being hit by the F-3 Cedar Park Tornado

3.8 BFRL Survey of Damage Due to the May 27, 1997, Central Texas Tornadoes

On May 27, 1997, a system of severe thunderstorms developed in the afternoon hours over Central Texas and moved southwesterly across this region. A series of tornadoes were spawned from this system and caused a significant number of deaths (28) and extensive damage to properties in four Central Texas counties (more than 280 homes and commercial buildings destroyed). The most deadly tornado, which was designated as an F-5 on the Fujita scale following the early damage survey, was the one that struck Jarrell, located between Waco and Austin, Texas.

Under the coordination of the Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM), members of BFRL and the National Weather Service (NWS) jointly conducted ground and aerial surveys to document the tornadoes' ground tracks, including estimates of their lengths and widths and the associated structural damage. Like many tornadoes in the past, the intensities of the Central Texas tornadoes were estimated and reported by comparing the physical damage to structures and objects in the affected region with the descriptive damage outlined by the F-scale. Since the F-scale also provides a range of wind speed for each intensity scale, inaccurate assignment of an F-scale could result in over- or underestimation of the tornado rotational wind speed. This in turn, could have a significant impact in the design profession. The observed structural damage documented by the NIST-NWS damage survey team provided a unique opportunity for comparing probable wind speed with that associated with the F-scale.

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In real world situations, these high performance materials help slow the spread of fire, allowing more time for passengers to safely leave a burning train car.

3.10 Fire Hazard Analysis for Trains

When a fire starts in an enclosed space, like a passenger train compartment, time for evacuation is of the essence. Everything about the design of the compartment – from the materials used for curtains, seats and carpets to the number of exits and the width of aisles – determines whether passengers will have enough time to exit a train car safely. As part of a three-year study of passenger train fire safety requirements for the Federal Railroad Administration (under the direction of the Volpe National Transportation Systems Center), Richard Peacock conducted full-scale tests in the BFRL large-scale fire research facility. Using bags of trash collected from in service trains, NIST researchers measured heat release rates to better understand the behavior of realistic fires. Peacock and his colleagues used these measurements with computer models to simulate how fires might spread in actual trains. Because these simulations take materials interactions and the size and arrangement of railway cars into account, they can often produce more realistic predictions of fire spread than materials testing alone. Even when exposed to very intense, direct flames, the train seats in the test charred rather than igniting and feeding the fire. In real world situations, these high performance materials help slow the spread of fire, allowing more time for passengers to safely leave a burning train car.

Contact: Mr. Richard Peacock, (301) 975-6664, richard.peacock@nist.gov

Fire protection engineer David Stroup explores the use of an infrared camera to determine details of fire spread and burning of the trash fire set near train seats

3.12 Protecting Fire Fighters

Over the past 20 years the protective clothing worn by firefighters has improved dramatically, giving the individual firefighter greater protection from fire, heat and moisture. Yet firefighters continue to suffer burns at a stubbornly constant rate. With support from the U.S. Fire Administration, BFRL's Fire Safety Engineering Division is examining the thermal environment of firefighters' protective clothing under stage and attack conditions of structural firefighting. The causes of these burn injuries are being elucidated by an improved understanding of the relationships among three factors. The critical factors are: the thermal environments surrounding firefighters when the injuries occur, the performance of the protective clothing itself and the activities and tactics of the firefighters that may contribute to the burn injuries. James Randall Lawson is leading the research effort aimed at developing the measurement tools and techniques needed to determine the performance of firefighters' protective clothing. Initially, Lawson examined the broad range of fire conditions and events that lead to burn injuries. Much fire research has focused on structural fires related to the design of buildings, their materials and contents, whereas little research has examined the thermal environment around firefighters while they are attacking a structural fire.

Fire Fighter turnout gear damaged during a fire that resulted in burn injuries

Firefighters avoid contact with the flaming envelope – that area bounded by the flame's edge. Many firefighter burn injuries are not caused by flame contact, but by factors such as contact with hot surfaces, excessive exposure to high thermal radiation and/or insufficient protection provided by protective clothing. In one scenario, a firefighter was burned even though the firefighter's protective clothing was wet on the inside from perspiration and on the outside from the splattering of the fire hose. Lawson has developed detailed recommendations for improving protective clothing including reducing and controlling the moisture inside the clothing. The report is specific about the need to inform and train firefighters about the performance limits of their clothing and strongly urges that firefighter training and tactics avoid placing the firefighter in an environment where the limit of the protective clothing is challenged.

Contact: Mr. James Randall Lawson, (301) 975-6877, jlawson@nist.gov

Awards & Staff Recognition

1997 NIST Bronze Medal

Ms. Geraldine S. Cheok was awarded the NIST bronze medal for pioneering experimental research which resulted in the development of hybrid-moment-resisting precast concrete beam column connections.

The Bronze Medal Award recognizes work that has resulted in more effective and efficient management systems and the demonstration of unusual initiative or creative ability in developing and improving methods and procedures and/or for significant contributions affecting major programs, scientific accomplishment within NIST, and superior performance of assigned tasks for at least five consecutive years.

1997 Distinguished Young Engineer Award

Dr. Gregory T. Linteris was selected by the Maryland Science Center as one of four to receive the 1997 Distinguished Young Engineer Award. A member of the NIST staff since 1992, Dr. Linteris was cited for his research on advanced fire suppressants and flame inhibition mechanisms. His work, as part of an international community of scientists and engineers, is concerned with finding alternatives to the ozone-depleting chemical halon 1301, upon which the modern world has depended for ensuring fire protection in industry, transportation, communications and defense systems.

Fire Protection Person of the Year – Automatic Fire Alarm Association

Mr. Richard Bukowski was presented with the Automatic Fire Alarm Association Fire Protection Person of the Year Award. This award is presented annually to the person who, in the opinion of AFAA's Board of Directors, has made a significant contribution to the Association's goal of advancing life safety in America. Mr. Bukowski received the award "In recognition of your countless hours of research in the fire detection field; efforts throughout your career to make the world safer through the use of smoke detection and fire alarm systems; dedication to finding the best way to apply detection principles for life safety in buildings; and work through the codes and standards process to ensure the proper use of detection and alarm systems."

1997 ACI Structural Research Award

Dr. William C. Stone and Ms. Geraldine S. Cheok are recipients of the ACI Structural Research Award in 1997 for their paper (Performance of Hybrid Moment-Resisting Precast Beam-Column Concrete Connections Subjected to Cyclic Loading) describing tests on and developing guidelines for precast moment frames using mild steel and post-tensioned tendons to develop the connections.

Federal Laboratory's Consortium Technology Transfer Award

Dr. Hunter Fanney and Mr. Brian Dougherty, received the Federal Laboratory's Consortium Award for excellence in technology transfer. This award recognized Federal laboratory employees who have accomplished outstanding work in the process of transferring laboratory developed technology. Fanney and Dougherty received the award for their patented research work related to solar photovoltaic hot water systems. The award was presented at the Federal Laboratory Consortium's National Technology Transfer Meeting in April 1997.

prototype of an intelligent method for effectively detecting various smoldering and flaming fires in the presence of interfering sources common to residential-type settings. When perfected, such a system would go
a long way toward eliminating the false alarm problems which can plague the current generation of fire and smoke detectors.

Patent for Heat Pump Performance Enhancing Device

The Building Environment Division has received a patent on a device to improve the cold weather performance of residential and light commercial air-source heat pumps. The device was invented by Mr. Peter Rothfleisch of the Thermal Machinery Group. Fundamentally, heat pumps utilize electrical power to extract heat contained in the outside air to heat the dwelling. However, the rate at which the heat pump is able to bring this heat energy into the house is directly proportional to the outside temperature. Consequently, on a cold day, heat pumps are unable to pump enough heat to match the heat loss of the dwelling. For this reason, heat pumps are equipped with auxiliary electric resistance heaters, which are turned on automatically when needed. This resistance heating is expensive for the homeowner and often causes a peak demand problem for the utility. The patented device is a distillation column that when utilized with a zeotropic refrigerant mixture is capable of changing the refrigerant mixture composition. By controlling the mixture composition, the heat pump capacity can be modulated in response to changes in the outdoor temperature. Thus, the distillation column enables the heat pump to maintain acceptable performance over a much wider temperature range and reduces the need for resistance heating. An additional benefit of the device is that the necessary zeotropic refrigerant mixture can be formulated from environmentally acceptable components.

ASME Fellow

Dr. William L. Grosshandler was named a Fellow of ASME International, formerly the American Society of Mechanical Engineers. The election to Fellowship recognizes the person's outstanding contribution to the technical community, as well as the support of organizations such as NIST to the profession. Dr. Grosshandler developed a research team and leads a world-class effort in the advanced technologies needed to identify new fire suppressants, obtain accurate flammability data for new refrigerants and help the U.S. fire detection industry succeed in global competitiveness.

Department of Defense Program Manager

Dr. Richard G. Gann has been named the first Technical Program Manager of the Department of Defense's Next-Generation Fire Suppression Technology Program (NGP). Supported by the Office of the Secretary of Defense, the 8-year, $46 million program has as its goal to develop and demonstrate, by 2004, halon 1301 alternative technologies that are easily retrofittable into current aircraft, ships and land combat vehicles. The new technologies will be applicable to a broad range of critical civilian applications as well. In addition to his position as Chief of the BFRL Fire Science Division, Gann will oversee projects conducted at university, industry and government laboratories.

Keynote Speaker at National Conference on Wind Engineering

Dr. Emil Simiu of the Structures Division was a keynote speaker at the 8th U.S. National Conference on Wind Engineering, Baltimore, MD, June 5-8, 1997. His talk "Toward a New Generation of Standard Provisions for Wind Loads" described innovative NIST activities conducted in collaboration with industry to improve significantly the risk-consistency and economy of structural design for wind.

Chair of NFPA's Committee on Alternative Approaches to Life Safety

Mr. David Stroup, of the Fire Safety Engineering Division has been selected to chair the National Fire Protection Association's Technical Committee on Alternative Approaches to Life Safety. This committee is responsible for developing NFPA 101A, Guide on Alternative Approaches to Life Safety. This guide consists of a number of different methodologies for evaluating life safety in buildings, each independent system is meant to be used in conjunction with NFPA 101, Code for Safety to Life in Buildings and Structures. Many of the systems described in the guide are derived from the Fire Safety Evaluation System developed at NIST in the late 1970's. The role of this committee is expected to grow as fire and building regulations in the United States shift from being compliance oriented to performance based.

C&B Activities in 1997

Creation and Development of the Partnership for Advancing Technology in Housing (PATH)

The Partnership for Advancing Technologies in Housing is being designed to bring together government and industry to develop, demonstrate and deploy housing technologies, designs and practices that can significantly improve the quality of housing without raising the cost of construction. The partnership, which will be made up of industry leaders who are willing to commit time and resources of their companies to help achieve the goals, has started with a core group of industry leaders to establish goals and define commitments from industry. The partnership will be housed in the Department of Housing and Urban Development (HUD). C&B will coordinate federal agency support for the organization and development of the partnership by holding meetings and identifying Federal experts and agency capabilities that can be used in the development of PATH goals and plans. The PATH program will include pilot developments at sites around the country where homes that meet the goals will be constructed and sold. C&B will also coordinate federal R&D effort in support of PATH goals and industry priorities and identify technologies that can be used in PATH pilot homes. C&B will play a key part in the development of a public outreach and publicity program for PATH.

These superinsulated duplexes look normal but they use only half the space heating energy of conventional houses, saving their owners about $200 each year

Working with Industries of Construction

In 1997 the Subcommittee on Transportation Infrastructure was integrated with C&B. C&B is now exploring the possibility of a broader program on civil infrastructure involving more than transportation. Two elements are likely to be part of this broader program; the Partnership for the Advancement of Infrastructure and its Renewal (PAIR), a partnership between government and industry, proposed by the Civil Engineering Research Foundation; and the Institute for Civil Infrastructure Systems (ICIS), a forum for addressing infrastructure issues planned by the National Science Foundation.

The CONMAT Council was formally established to implement the high-performance CONstruction MATerials and systems program designed to create a new generation of constructed facilities. The Council consists of 12 different material groups (aluminum, coatings, concrete, fiber-reinforced composites, geo-synthetics, masonry, plastics, roofing materials, smart materials, stainless materials, steel and wood) as well as liaison members from public and private agencies, with CERF acting as secretariat. These groups have joined forces in a $250 million effort to plan and implement a national program of research development and deployment. CONMAT provides an excellent mechanism to align federal R&D with industry programs for advanced construction materials and systems. The use of high performance materials is a key factor in achieving many of the National Construction Goals.

Outreach

The Laboratory has made a concerted effort to improve communication with the building and fire communities through printed and electronic media. To provide detailed information on our technical programs and products, three special publications have been released, *Project Summaries, Publications and Impacts*. These documents have been produced annually, so BFRL also publishes a full color quarterly newsletter *Research Update,* which is mailed to about 5000 recipients.

For more than three years BFRL has had a site on the World Wide Web and is redesigning its organization to include more news items such as those appearing in *Research Update* and provide easier access to items of interest to users. In addition to the Web site BFRL maintains an intranet on its local area network for use by BFRL staff only. This intranet improves communications within the laboratory and makes more information easily available to staff in an electronic format.

Collaboration with Industry

The Building and Fire Research Laboratory's "strategy for success" is to build on the ties that have been developed to identify research needs and to focus our program on the development of products that will meet those needs. Direct research under Collaborative Research and Development Agreements (CRADA's) with individual companies or consortia is the most direct method of meeting the needs of industry.

Industry Consortia

NIST works with industry consortia in a number of areas including the demonstration of a standard communication protocol for building automation and control systems (BACnet), application protocol for the process plant industries (PlantSTEP), the prediction of the service life of coatings, the development of a methodology for evaluating seams of rubber roofing membranes and advanced environmentally-friendly and fire-safe materials.

NIST has expanded its cooperative research and development agreement to include 22 partners to develop interoperable building control equipment that communicates using the BACnet protocol. The objective of the consortium is to assist the member companies in developing products that conform to the BACnet standard and to develop conformance testing tools and procedures that can be used to establish an industry-run certification program. It will also provide a way to interconnect traditionally stand-alone building control systems such as HVAC, fire, lighting and security. NIST has developed test methods and software testing tools and provided facilities for member companies to bring their prototype products together for testing. The following partners make up the BACnet consortium: Alerton Technologies andover Controls, Automated Logic, Auto-Matrix, Carrier, Cimetrics Technology, Cornell University, Delta Controls, Honeywell, Johnson Controls, KMC Controls, Landis and Stafea, McQuay International, Orion Analysis, Phoenix Controls, PolarSoft, Siebe Environmental Controls, Simplex, Teletrol, Systems, Trane and York.

NIST worked with industry to establish PlantSTEP, Inc., an industry consortium supporting the development of information exchange standards for the process, power and construction industries. PlantSTEP membership (20 companies as of December 1997) includes companies that own, operate, engineer, construct, or supply materials for process plants and over 90% of the vendors of 3D plant design systems. In collaboration with PlantSTEP, NIST developed the Plant Spatial Configuration AP (AP 227) which supports the 3D design and engineering of process plants, with an emphasis on piping design. The PlantSTEP/NIST team completed the Draft International Standard version of AP 227 and ISO circulated AP 227 for ballot in September 1997. Consortium members are: Bechtel, Black & Veatch, Eastman Chemical, E. I. DuPont & Co., H.B. Zachry, Merck & Co., Air Products & Chemicals, Autodesk, Bentley Systems, CADCentre, Computervision, Dassault Systems of America, EA Systems, Hitachi, Intergraph, Jacobus Technology, John Brown Systems, Rebis, Shaw/Sunland and Toshiba.

The NIST-led Consortium on Service Life Prediction of Coatings has completed its third year and plans for a second three-year phase are now being drawn up. Apart from NIST, its members are Atlas Electrical Devices, Courtaulds International, Dow Chemical, DuPont, Duron, Eastman Chemical, National Renewable Energy Laboratory, PPG, Rhom and Hass, South Florida Test Sites and the Federal Highway Administration.

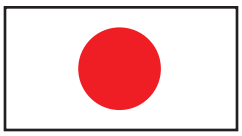
The NIST-led Consortium on Tape-Bonded Seam for EPDM Roofing Membranes has been successful in showing that adhesive tapes perform at least as well as liquid-applied adhesives under the conditions investigated so far. The work will be completed in fiscal year 1998. Apart from NIST, the members are Firestone Rubber Company, Carlisle-Syntec, Ashland Chemical, the National Roofing Contractors Association and the Roofing Consultant Institute.

Canada

BFRL and the Institute for Research in Construction (IRC) of the National Research Council of Canada (NRCC) signed an agreement in October 1997 to identify areas for collaborations that will increase each laboratory's productivity and effectiveness, improve the performance and economy of constructed facilities and increase the productivity and competitiveness of the industries of construction. Areas for collaborations include: 1) laboratory, field and analytical research; 2) measurement and test methods; 3) recommendations for national and international standards; 4) conducting workshops with industry, academia and government agencies; 5) laboratory visits and exchanges of staff; 6) exchanges of information and 7) joint planning.

The Building Environment Division and IRC are completing a three-year research project (1995-1997) that developed a computer program for promoting acceptable indoor air quality in the design and operation of buildings. The computer program predicts ventilation performance and contaminant levels in a building before construction and analyzes ventilation and indoor air quality in existing buildings.

Robert Zarr of the Building Environment Division, Eric Lagergren of ITL's Statistical Engineering Division and M. Kumaran of the IRC performed conductivity measurements from an international interlaboratory study for glass-fiber board and fibrous alumina silica. The measurements were determined using guarded hot plate apparatuses at BFRL and the IRC. North America manufacturers of thermal insulation must satisfy the thermal performance requirements promulgated by the U.S. and Canada to market their products in both countries. This interlaboratory study was initiated in 1993 and completed in 1997.



Japan

U.S.-Japan Cooperative Program in Natural Resources

The U.S.-Japan Cooperative Program in Natural Resources (UJNR) was created in January 1964; one of three programs comprising the U.S.-Japan Cooperative Science Program. BFRL co-chairs two of the 19 Panels.

Fire Research and Safety Panel

The Fire Research and Safety Panel explores the chemistry and physics of fires. It encourages, develops and carries out the exchange of information and data in fire and smoke physics, toxicity, chemistry and risk and hazard evaluation; promotes cooperative research in areas of fire safety and combustion toxicity; encourages innovations in the development of risk assessment methods, fire test methods and design standards; establishes multinational consensus of computer-based fire modeling; develops the basis for performance fire codes; and develops new fire protection and prevention technology appropriate to modern products and design. The 13th joint meeting of the panel was held at NIST in March 1996; its 14th meeting will be held in Japan later this year.

U.S.-Japan collaborative research has enabled staff to maximize the strengths of each country's laboratory facilities. The panel has advanced fire science and technology in areas such as fire-smoke toxicity; fire detection; microgravity combustion; thermal degradation of polymers; intumescent polymer burning; wall fire modeling; smoke flow in buildings; building fire modeling; and rate of heat release measurements. Collaborative research has led to a new option for housing; a new method for testing fire smoke toxicity; the formation of an international fire safety science association; and access to unique fire research facilities in both countries. In its 22-year history, the members have exchanged more than 40 guest researches in fire research and safety.

The panel co-chairs are: Dr. Jack Snell, U.S.-side panel, Deputy Director, Building and Fire Research Laboratory and Dr. Tsutoma Shimazaki, Japan-side panel, Director-General, Building Research Institute.

Common Agenda's Natural Disaster Reduction

The Common Agenda is an agreement between the President of the United States and the Prime Minister of Japan to join policy level officials and technical specialists from the United States and Japan to identify earthquake research and policy issues and seek agreement on cooperative projects to mitigate their impact through improved monitoring and by strengthening research and response countermeasures. BFRL participates in two thrusts of the Natural Disaster Reduction Initiative.

Earthquake Policy Symposium

The second Earthquake Policy Symposium was conducted in September 1997, Kobe Japan. BFRL played a major role in planning the first and second symposium. Two central themes ran through the symposium:

- research is required to address the long term nature of earthquakes as they confront both countries and
- effective disaster information deployment methods are needed to share research findings and disaster-reduction policy information with government and academic laboratories and with the public.

In realizing these themes, the U.S. and Japan members agreed to confront three topics by exchanging:

- real-time seismic information systems for use in disaster-prevention and response policy,
- loss estimation models in emergency prevention, preparedness and response and
- post-earthquake response and recovery policies for prevention of future losses.

Both countries will develop a plan to address these topics within a year. In preparation for this venture, they will seek linkages with appropriate U.S.-Japan programs such as the UJNR Panels (see above) and with appropriate respective agency programs to coordinate and focus related work.

Earthquake Disaster Mitigation Partnership

Also, in September 1997, the U.S.-Japan Earthquake Disaster Mitigation Partnership met in Kobe to review proposed joint cooperative research projects. The priority areas for cooperation include quantifying future earthquake potential; strengthening loss estimation methods; testing basic theories of the earthquake source; understanding near source motions; geological effects and structural response; reducing seismic risks posed by steel buildings; strengthening, evaluating and retrofitting of existing and damaged buildings and infrastructure; developing performance-based design methods; developing real-time seismic information systems; and controlling post earthquake fires.

Forty-three joint research projects were endorsed. NIST is responsible for seven projects that center in BFRL's Structures Division and Fire Safety Engineering Division. Mechanisms for carrying out the Partnership included relying on the UJNR Panels (see above) and on other bilateral linking methods available in the participating agencies; symposia and workshops that address specific topics under the Earthquake Policy Symposium; and other methods identified by the collaborators. The U.S. and Japan sides will convene respective agency meetings throughout the year to initiate work on their respective projects. An annual report on the mission and activities of the partnership will be developed by March 1998. The next full meeting of the U.S.-Japan Partnership will be held with the Earthquake Policy Symposium High Level Forum scheduled in the fall of 1998.

Microgravity Experiments

Takashi Kashiwagi conducted microgravity experiments in the Japan Microgravity Center (JAMIC) drop tower with scientists from NASA and JAMIC. This work was coordinated with the microgravity experiments performed on space shuttle Columbia.

Multilateral Activities

The Process Industry Executive for Achieving Business Advantage using Standards of Data Exchange (PIEBASE) is an international umbrella organization for process industry active development of Standard for the Exchange of Product model data (STEP) and other standards for industrial data. Mark Palmer of the BFRL Computer Integrated Construction Group participates in the PIEBASE executive group and leads the PIEBASE Working Group 2 on process plant engineering activity models.

C System Performance: The Practical Application of Fault Detection and Diagnosis Techniques in Real Buildings. Ten countries participate in the Annex. Members of the U.S. team, in addition to NIST, include Johnson Controls Inc., the Honeywell Center, MIT, Purdue University and Field Diagnostic Services, Inc. The objective of Annex 34 is to work with control manufacturers, industrial partners and/or building owners and operators to demonstrate the benefits of on-line performance evaluation in real building applications. The fault detection and diagnostic (FDD) methods developed in Annex 25 are to be combined into robust performance evaluation systems and incorporated into a future generation of smart building control systems.

International Committee Participation

International Council for Building Research and Documentation (CIB)

BFRL is a member of CIB and actively participates in many of its task groups and working commissions. CIB is concerned with fostering international cooperation and information exchange in building construction and research as well as technology development and documentation and as such provides an important channel for international pre-standardization activity in this field. Jack Snell serves on the Board of Directors and the Program and Administrative Committees of CIB. Current CIB priorities include sustainable development, performance based standards, construction process re-engineering, better service to its members in the Americas and Asia and in expanding its role as a pre-standardization body.

Organization for Economic Cooperation and Development (OECD)

Barbara Lippiatt of BFRL's Office of Applied Economics was an invited member of the U.S. Delegation to the OECD conference on Greener Public Purchasing held in Switzerland. Lippiatt presented the Building for Environmental and Economic Sustainability (BEES) methodology at the conference. Lippiatt published the BEES methodology in January 1998 as Windows-based decision-support software for the Federal procurement community for selecting products that achieve the most appropriate balance between life-cycle environmental, economic and technical performance. This work was sponsored in part by the Environmental Protection Agency.

Major Conferences, Seminars and Workshops

Forum for International Cooperation on Fire Research (FORUM)

The Forum for International Cooperation on Fire Research (FORUM) comprises heads of public and private sector fire research laboratories and organizations sponsoring fire research around the world. Jack Snell is the chair of the Forum and Richard Bukowski is the secretary. The group meets annually to discuss mutual interests, encourage cooperative undertakings and promote the advancement of fire safety engineering. Typically, the FORUM sponsors a two-day workshop with the host member to highlight some important issue or aspect of fire safety engineering in the host's nation. The fiscal year 1996 meeting was held in Norway and the symposium focused on issues associated with development and implementation of a performance based standard in that country. The fiscal year 1997 meeting in Tainjin, China addressed issues of fire research and testing and the codes and standards processes in China.

International Workshop on the Fire Performance of High-Strength Concrete (HSC)

An international workshop on the fire performance of high-strength concrete (HSC) was sponsored by BFRL in February 1997 in collaboration with Mobil Technology Company, Dupont Engineering and Portland Cement Association. The workshop focused on identifying the technical challenges associated with the performance HSC under fire conditions and the research needed to provide solutions for those challenges. The workshop brought together leading researchers, representatives of trade organizations, government regulators from nine different countries, including Canada, Finland, France, Germany, Norway, Sweden, Taiwan, United Kingdom and the United States. The workshop commenced with technical presentations by various researchers, followed by four concurrent working group sessions addressing topics of material testing, element testing, analytical studies and codes and standards for fire-exposed HSC. A workshop proceedings, which includes technical papers and recommended research needs, is now available.

International Workshop on Seismic Design Methodologies

H.S. Lew of the BFRL co-organized the International Workshop on Seismic Design Methodologies for the Next Generation of Codes that was sponsored jointly by the US-Slovene Joint Board for Scientific and Technological Cooperation, Office of International and Academic Affairs/NIST and the National Science Foundation.

International Conference on Roofing Technology

The 4th International Conference on Roofing Technology was held at NIST on September 17-19, 1997. The conference was sponsored by NIST, the National Roofing Contractors Association and several other organizations. It was attended by about 450 persons from 22 countries. Walter Rossiter served on the planning committee.

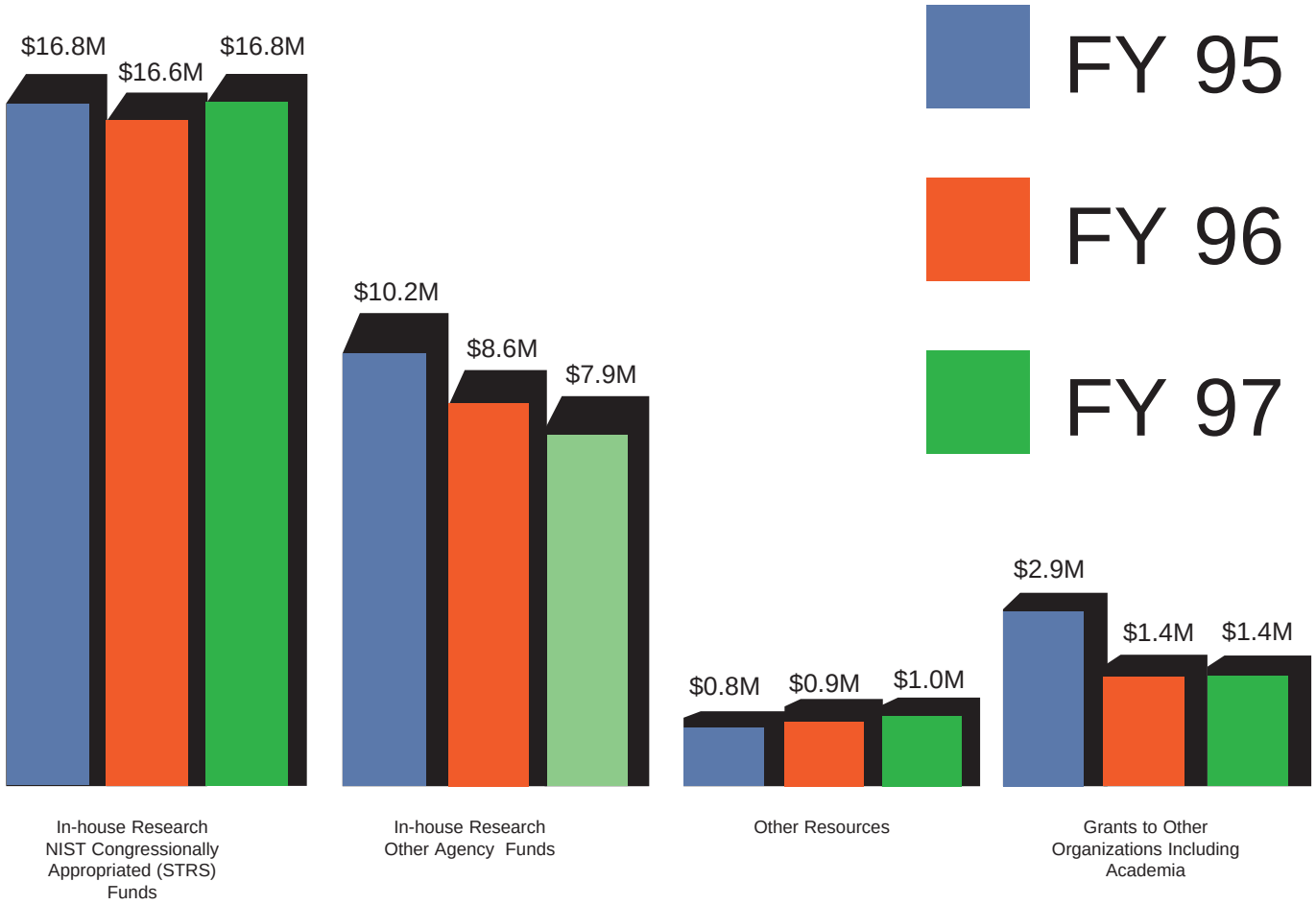
Green Building Conference

NIST, as represented by the Building Environment Division, join with the U.S. Green Building Council, the American Institute of Architects and the San Diego Gas and Electric Company to sponsor the "Third International Green Building Conference". Green buildings are defined as those designed, constructed, operated and demolished in ways that have a minimum impact on their global neighborhood and internal environments. The conference, held in San Diego, CA, November 17-19, 1996, brought together experts in the field of green buildings. Approximately 300 people attended this conference, including representatives from industry, academia and government. International professionals presented the latest information on sustainable practices, materials and technologies. The proceedings from the conference are published in NIST Special Publication 908, *"Third International Green Building Conference and Exposition – 1996"*.

ASHRAE/NIST Refrigerants Conference

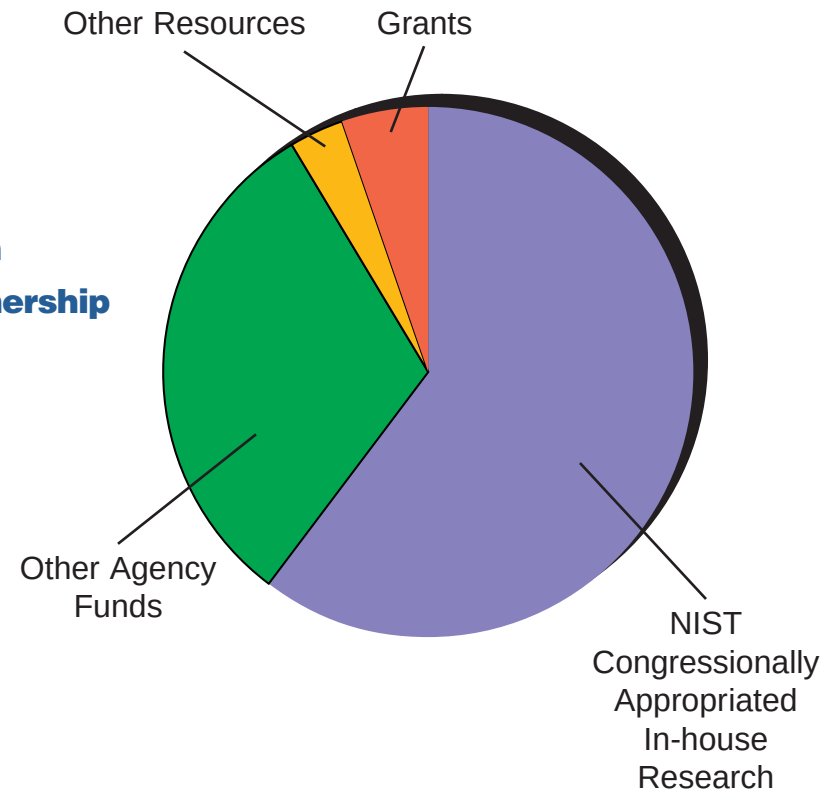
Refrigerant options for air-conditioning and refrigeration industry in response to ozone depletion and climate change were the topic of the third refrigerant conference jointly organized by the American Society of Heating, Refrigerating and Air-Conditioning Engineers and the National Institute of Standards and Technology. The conference entitled "Refrigerants for the 21st Century" took place on October 6 and 7 at NIST. While the first two conferences organized in 1989 and 1993 were related to

Finances



Note – Other resources include:

Advanced Technology Program
Manufacturing Extension Partnership
Standard Reference Materials
Expense and Income



Building and Fire Research Laboratory

The functional statements of the Building and Fire Research Laboratory and the Offices, Divisions and Groups in the laboratory are as follows:

BUILDING AND FIRE RESEARCH LABORATORY OFFICE

Responsible for planning, directing and implementing the scientific, technical and administrative programs of the Laboratory through scientific, administrative and support personnel.

OFFICE OF APPLIED ECONOMICS: Supports the BFRL research and BFRL technology deployment to government agencies and construction and fire-related industries; provides standardized economic methods, economic models, training programs and materials and expert technical consulting in support of resource allocation decisions; and uses techniques such as benefit-cost analysis, life-cycle costing, multi-criteria decision analysis and econometrics to evaluate new technologies, processes, government programs, legislation and codes and standards to determine efficient alternatives.

OFFICE OF COOPERATIVE RESEARCH: Facilitates the transfer of scientific and technical output of the Building and Fire Research Laboratory to the user community; manages the cooperative building and fire research programs with other federal agencies and national and international private organizations; and develops cooperative research programs with other federal agencies and agencies of foreign governments.

STRUCTURES DIVISION (Chief: Dr. S. Sunder 301-975-6713)

Increases the productivity and safety of building construction by providing technical bases for improved structural and earthquake design criteria; conducts laboratory, field and analytical research in structural engineering which includes: investigation of important structural failures, characterization of normal and extreme loads on buildings occurring during construction and in service, associated structural response and methods for providing desired reliability, development of design criteria for reduction of risks from natural hazards, evaluation methods and criteria for safe and economical construction practices, engineering properties of soils and foundations and nondestructive evaluation methods and criteria for increasing structural properties.

STRUCTURAL EVALUATION GROUP: Conducts laboratory, field and analytical research in structural engineering when activities include: development of nondestructive evaluation methods and criteria for assessing structural properties; development of methods for the identification of dynamic response characteristics of flexible members and structural networks; development of technical criteria and methodologies for the strengthening and repair of structural members and systems; characterization of normal and extreme loads on buildings during construction and in service; and investigation of important structural failures.

EARTHQUAKE ENGINEERING GROUP: Provides research data and technical support for the development and application of seismic design and construction practices for new and existing buildings and lifelines when activities include: laboratory and analytical studies needed for improving codes and standards pertaining to new construction; the development of criteria regarding the repair and strengthening of existing structures; the development of procedures to evaluate the response of structural systems to seismic loading; post-earthquake investigations to ascertain the effectiveness of design and construction practices in actual earthquakes; and technical support to the National Earthquake Hazards Reduction Program (NEHRP).

Building and Fire Research Laboratory

FIRE SAFETY ENGINEERING DIVISION (Chief: Dr. David Evans, 301-975-6863)

Performs research on and develops engineering methods for fire safety engineers, manufacturers and other Federal agencies to predict the behavior of fire and smoke and assess various means to mitigate the impact of fire on people, property and the environment. This includes developing and demonstrating the application of analytical tools to building fire problems; developing analytical models for the quantitative prediction of the threats to people and property from fires and the means to assess the accuracy of those models; developing techniques to predict, measure the behavior and mitigate the impact of large fires; and operating the Fire Research Information Service and the Fire Research large-scale fire test facility.

LARGE FIRE RESEARCH GROUP: Performs research on and develops techniques to measure, predict the behavior of and mitigate large fire events. This includes: understanding the mechanisms in large fires that control the gas phase combustion, burning rate, thermal and chemical emissions and transport processes; developing techniques for computer simulation; developing field measurement techniques to assess the near- and far-field impact of large fires and their plumes; performing research on the use of combustion for environmental cleanup; predicting the performance and environmental impact of fire protection measures and fire fighting systems and techniques; and developing and operating the Fire Research Program large-scale experiment facility.

FIRE MODELING AND APPLICATIONS: Performs research, develops and demonstrates the application of analytical models for the quantitative prediction of the consequences of fires and the means to assess the accuracy of those models. This includes: developing methods to assess fire hazard and risk; creating advanced, usable models for the calculation of the effluent from building fires; modeling the ignition and burning of furniture, contents and building elements such as walls; developing methods of evaluating and predicting the performance of building safety design features; developing a protocol for determining the accuracy of algorithms and comprehensive models; developing data bases to facilitate use of fire models; and operating the Fire Research Information Service which serves as a central source of information for the fire community.

FIRE SCIENCE DIVISION (Chief: Dr. Richard G. Gann, 301-975-6864)

Performs research on and develops scientific and engineering understanding of fire phenomena and metrology for fire research; produces principles, metrology, data and predictive methods for the formation/evolution of smoke components in flames and for the burning of polymeric materials; and develops science and predictive methods to enable high-performance fire detection and suppression systems.

SMOKE DYNAMICS RESEARCH GROUP: Produces scientifically sound principles, metrology, data and predictive methods for the formation/evolution of smoke components in flames for use in understanding and predicting general fire phenomena which includes: research on the effects of within-flame and post-flame fluid mechanics on the formation and emission of smoke, including particulates, aerosols and combustion gases; understanding the mechanistic pathway for soot from chemical inception to post-flame agglomerates; and developing calculation methods for the prediction of the yields of CO (and eventually other toxicants) as a function of fuel type, availability of air and fire scale.

FIRE SENSING AND EXTINGUISHMENT GROUP: Develops understanding, metrology and predictive methods to enable high-performance fire sensing and extinguishment systems; devises new approaches to minimizing the impact of unwanted fires and the suppression process which includes: research for the identification and in-situ measurement of the symptoms of pending and nascent fires or explosions and the consequences of suppression; devising or adapting monitors for these variables and creating the intelligence for timely interpretation of the data; determining mechanisms for deflagration and detonation suppression by advanced agents and principles for their optimal use; modeling the extinguishment process; and developing performance measures for the effectiveness of suppression system design.

MATERIALS FIRE RESEARCH GROUP: Performs research to understand fundamentally the mechanisms that control the ignition, flame spread and burning rate of materials and the chemical and physical characteristics that affect these aspects of flammability; develops methods of measuring and predicting the response of a material to a fire which includes: characterizing the burning rates of charring and non-charring polymers and composites; delineating and modeling the enthalpy and mass transfer mechanisms of materials combustion; and developing computational molecular dynamics and other mechanistic approaches to understand the relationships between polymer structure and flammability.